FNAL/ANL Processing and Analysis of PreCam Data

(with a bit about hardware too)

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In this talk...

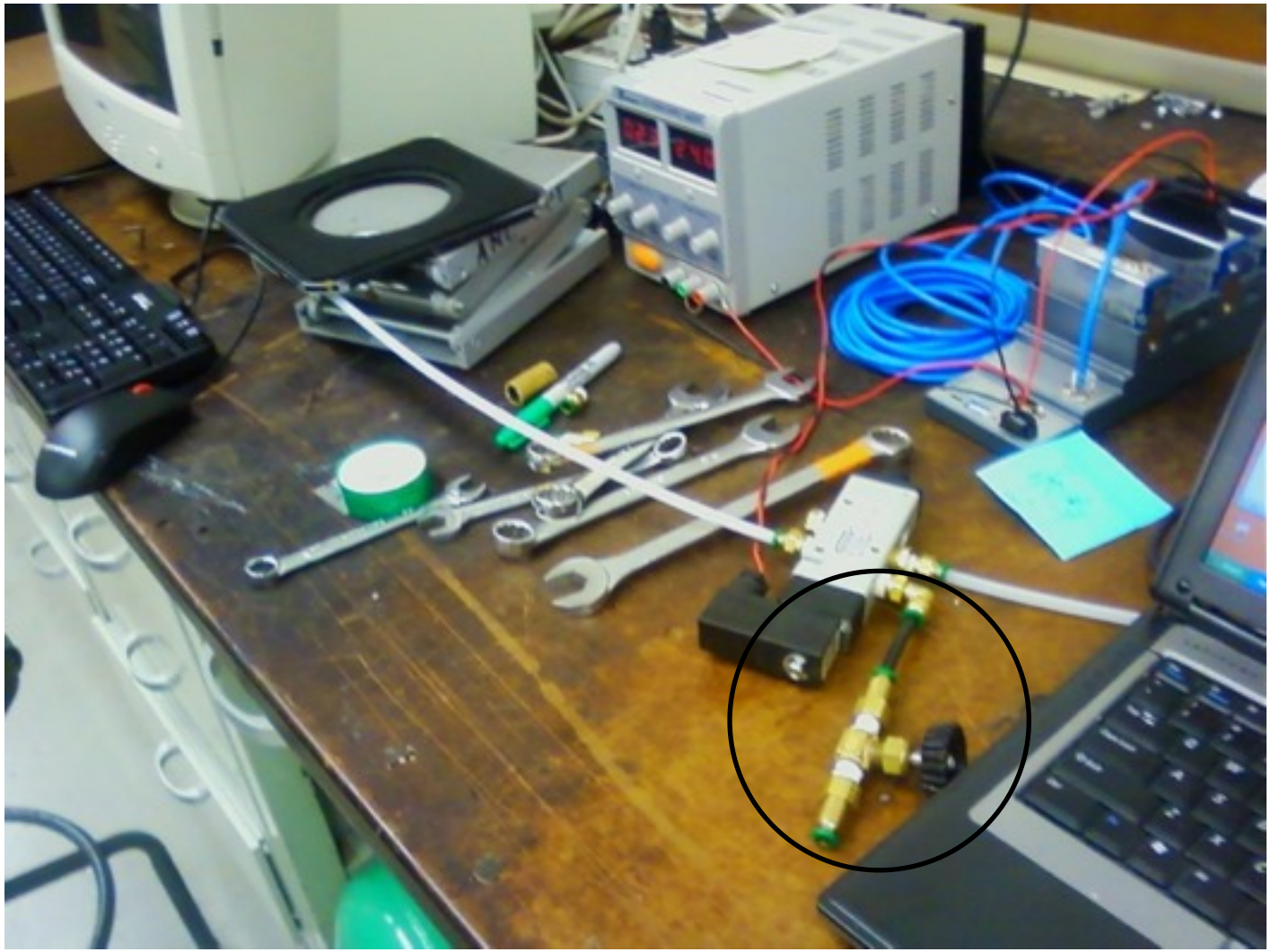
- Hardware
  - VIB Cables “fixed”, strain relief shipped
  - Shutter: >45k actuations in 6 positions, no failures (~10-20% of all actuations directly observed), thanks to slow-release valve...

- Overview of processing: v1, v2, **v3**
- FNAL/ANL shell/py scripts:
  - Bias, flat, dark, etc. (standard processing)
  - Streaking correction
  - Stuck shutter image identification
  - shutter timing & illumination map corrections
- ANL root scripts incorporating star flat corrections, data selection criteria--particularly FWHM, stellarity, magnitude (error)

- Results: Astrometry and Photometry for USNO, South, SDSS
- Other cool products: Montage, SNe in PreCam

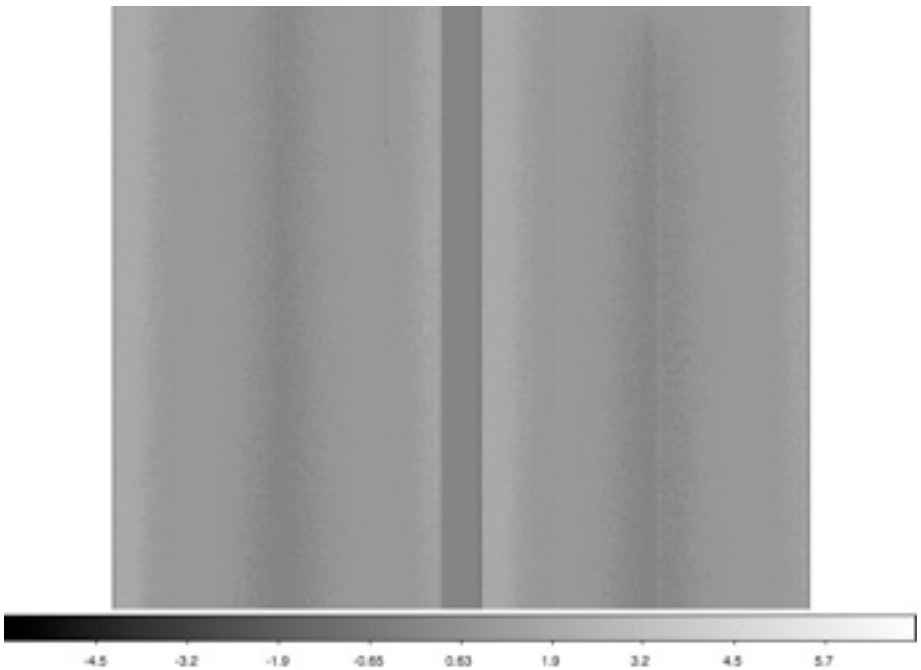
- To Do: Alternate photometric solutions (DAOPHOT, PSFEx), any additional errors (SDSS reCal?), FNAL/ANL scripts to Brazil pipeline
- PUBLISH!


PreCam

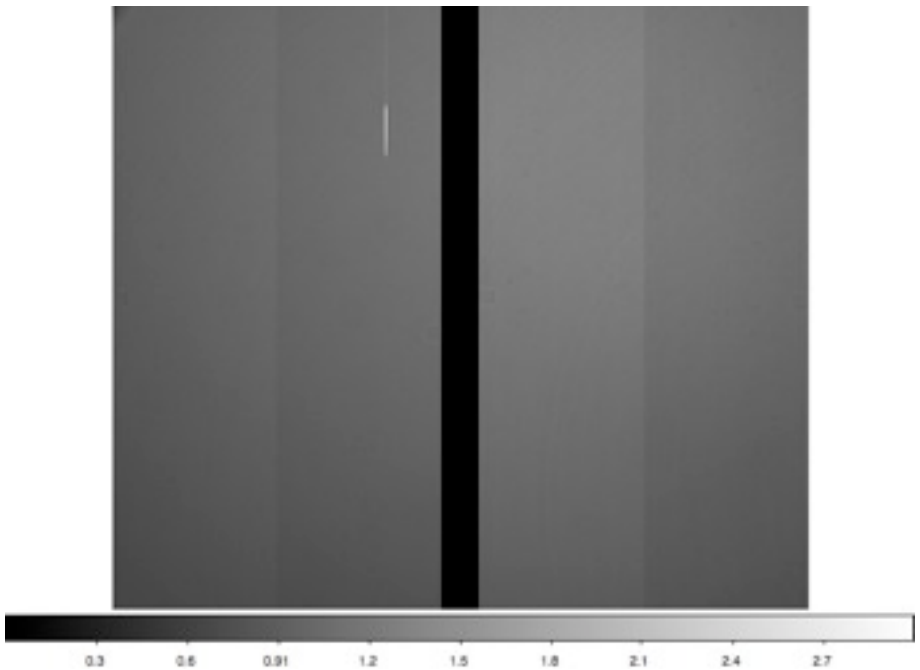


FNAL v1, v2, v3 processing (doc-db#5872)

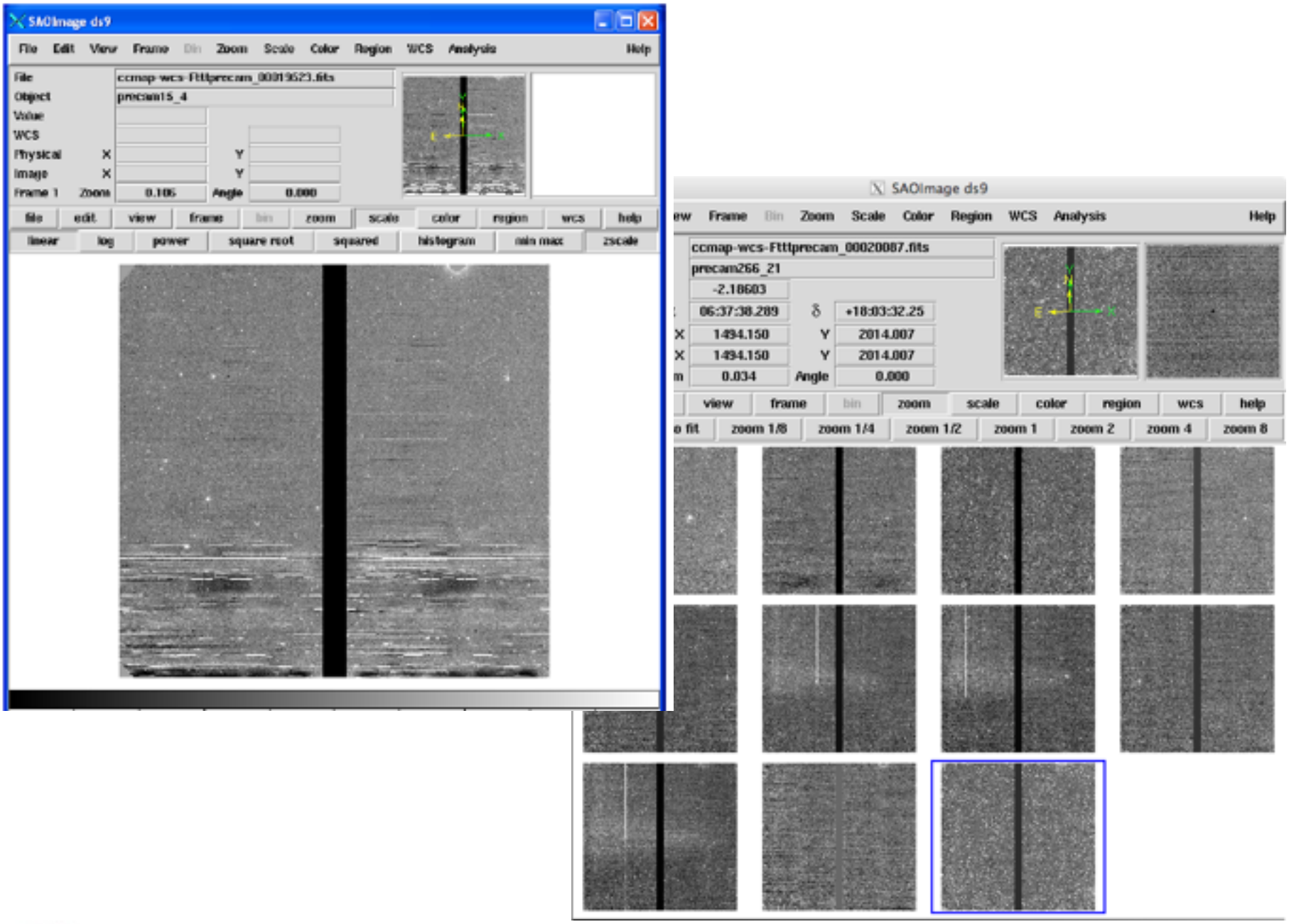
- Fermilab developed a processing pipeline consisting primarily of shell and py scripts for bias subtraction, flat-field corrections, etc.
- Each iteration added functionality--crucial improvements include banding/streaking removal, astrometry
- since v3, shutter timing maps and stuck shutter identification and correction algorithms have also been developed



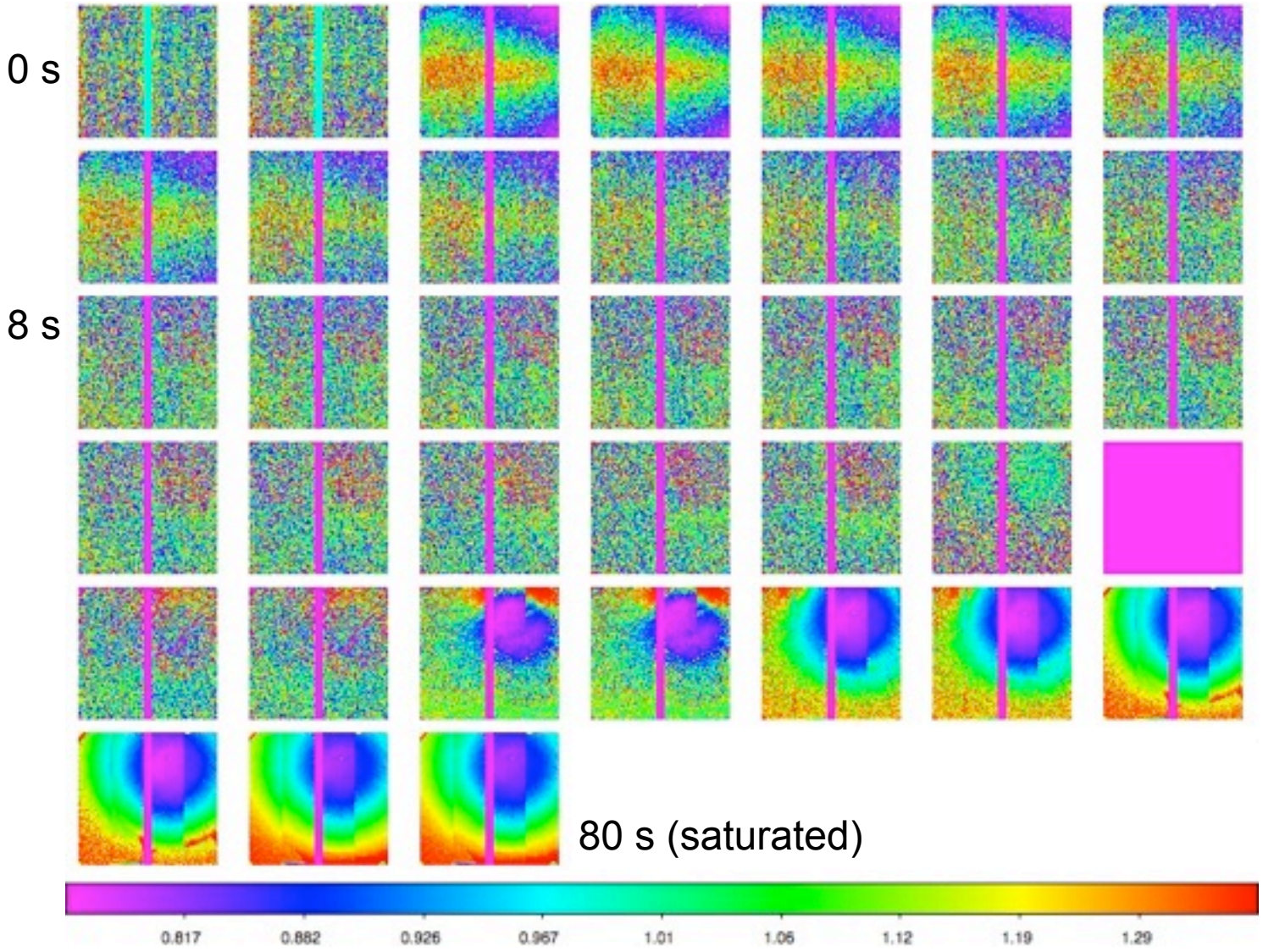
Bias



Flat


SAOImage ds9
File Edit View Frame Bin Zoom Scale Color Region WCS Analysis Help
ccmap-wcs-Fttprecam_00020087.fits
precam266_21
-2.18603
06:37:38.289
+18:03:32.25
1494.150
2014.007
0.034
0.000
file edit view frame bin zoom scale color region wcs help
linear log power square root squared histogram min max zscale
view frame bin zoom scale color region wcs help
zoom 1/8 zoom 1/4 zoom 1/2 zoom 1 zoom 2 zoom 4 zoom 8

From Photon Transfer Curve data: Shutter Timing effects are negligible beyond ~8s.



FNAL v3+ Processing Status

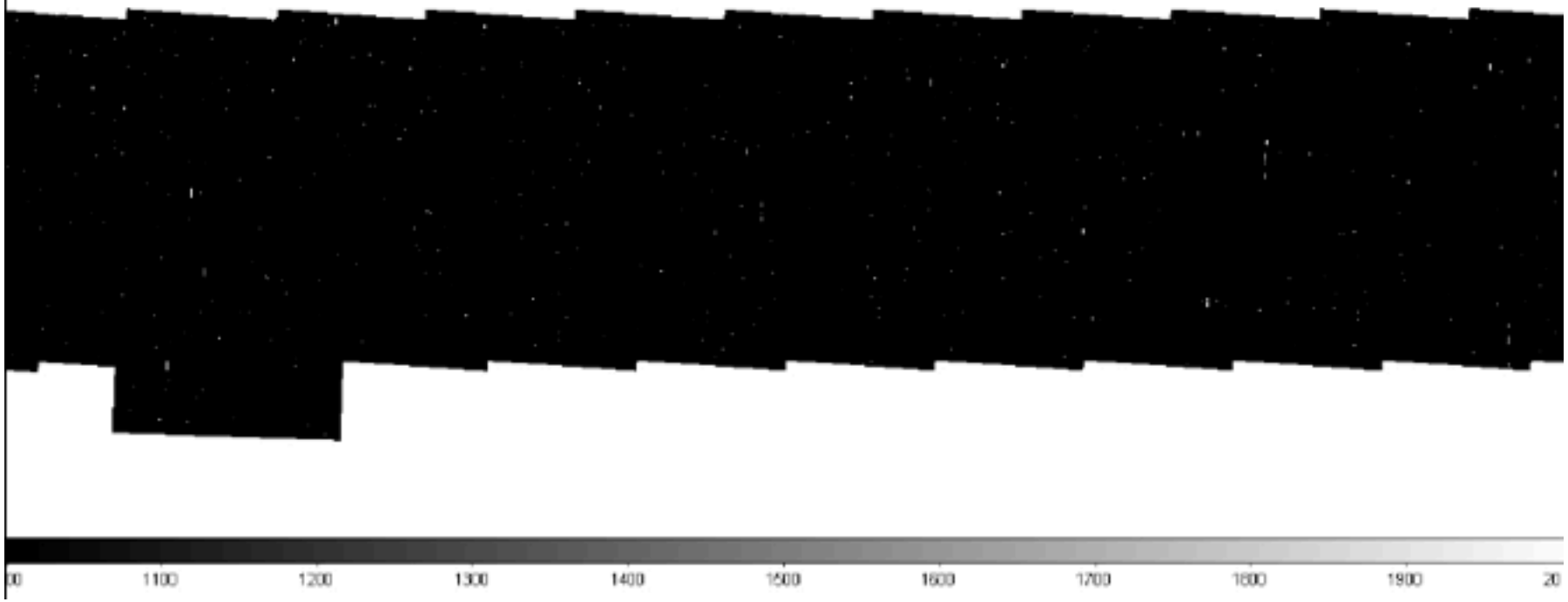
- comprehensive bad file list compiled
- corrections for streaking, stuck shutter, shutter timing, etc. applied
- (nearly) all files completely processed, *.cat files produced

Argonne has been hard at work in parallel...

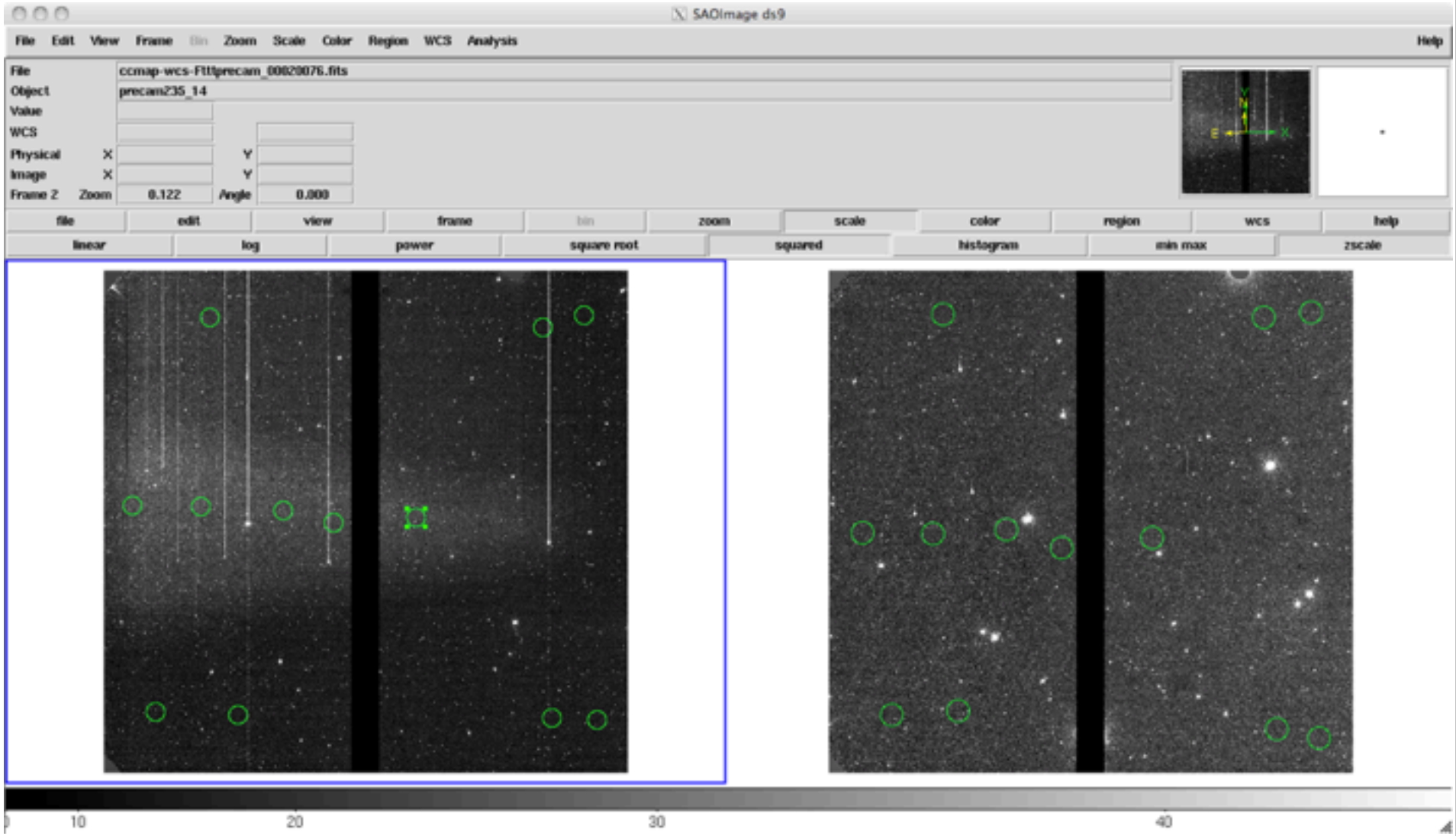
- (Hardware: shutter improvements, VIB Cable strain relief)
- Montage!
- Additions to processing including independent stuck shutter identification, as well as illumination correction (secondary flat field due to shutter or other instrumental effects, and dipoles/artifacts from streaking correction algorithm) --> new .cat files
- Analysis tools (primarily root scripts) developed and applied to Golden Nights

Montage!

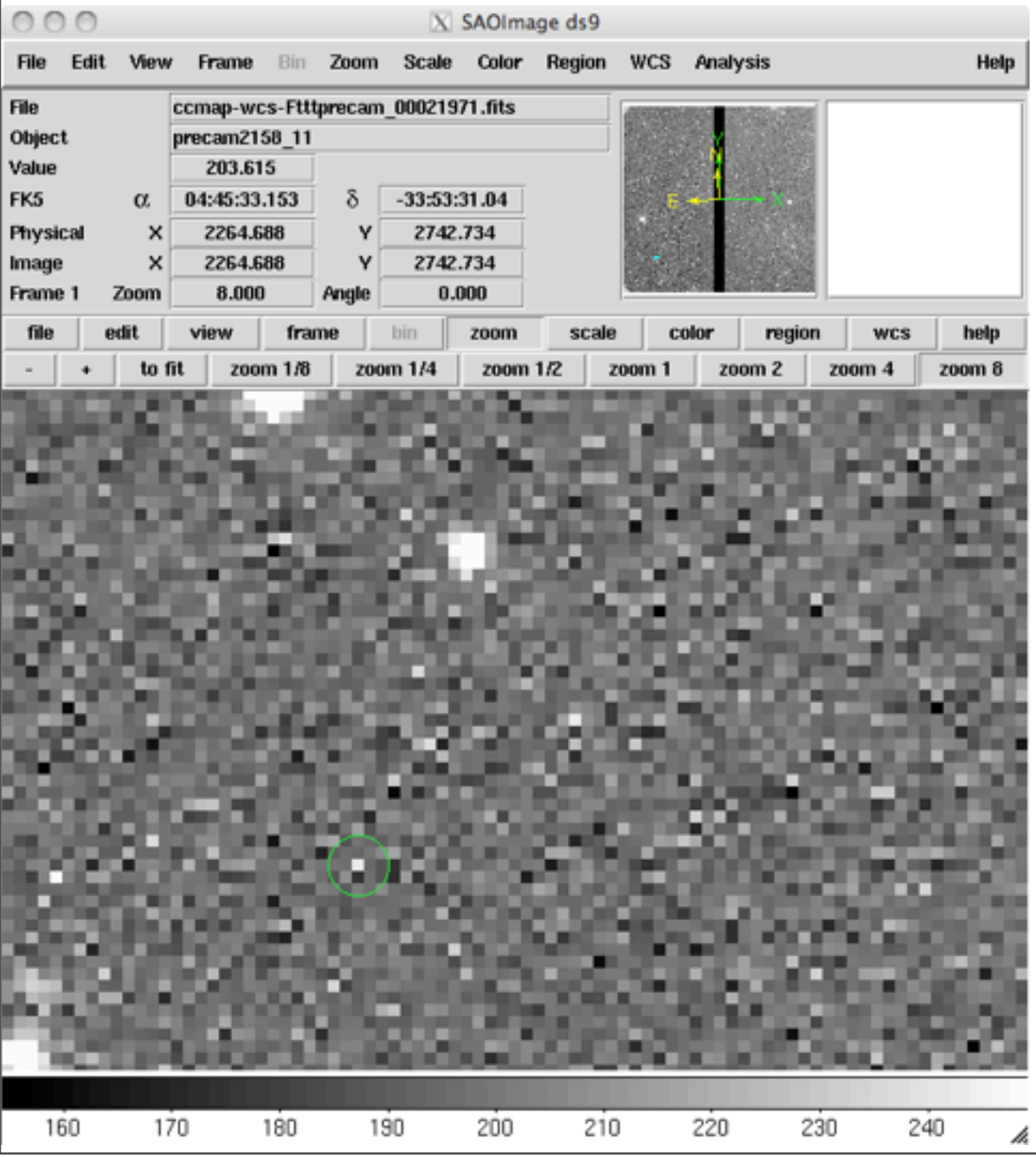
53-image i-band only PreCam mosaic of Stripe 82, with scale chosen to hide CCD gaps. Processing took 1 minute. Also used Montage feature of pixel-averaging to shrink combined FITS file by x20.



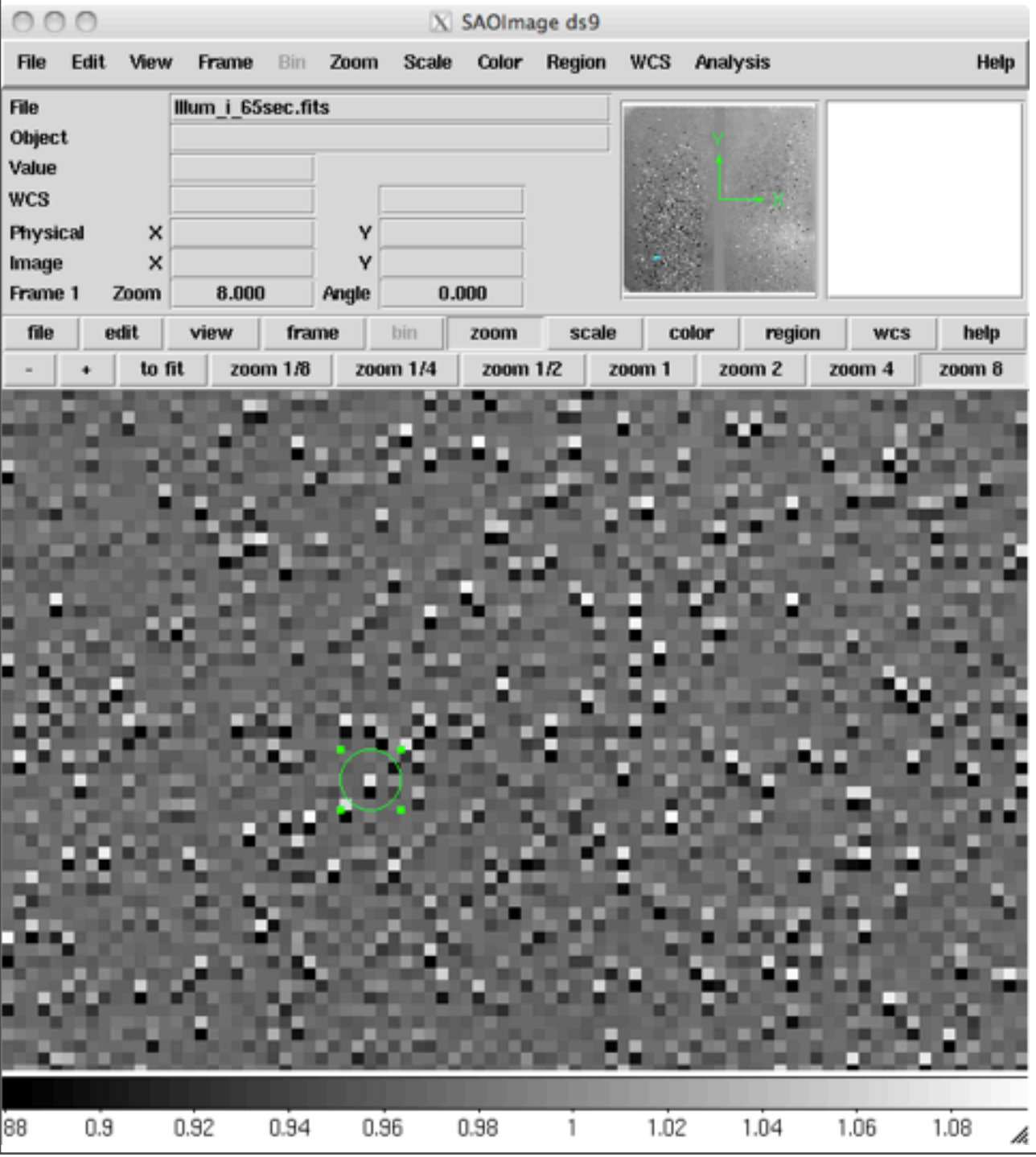
Shutter Stuck? Test



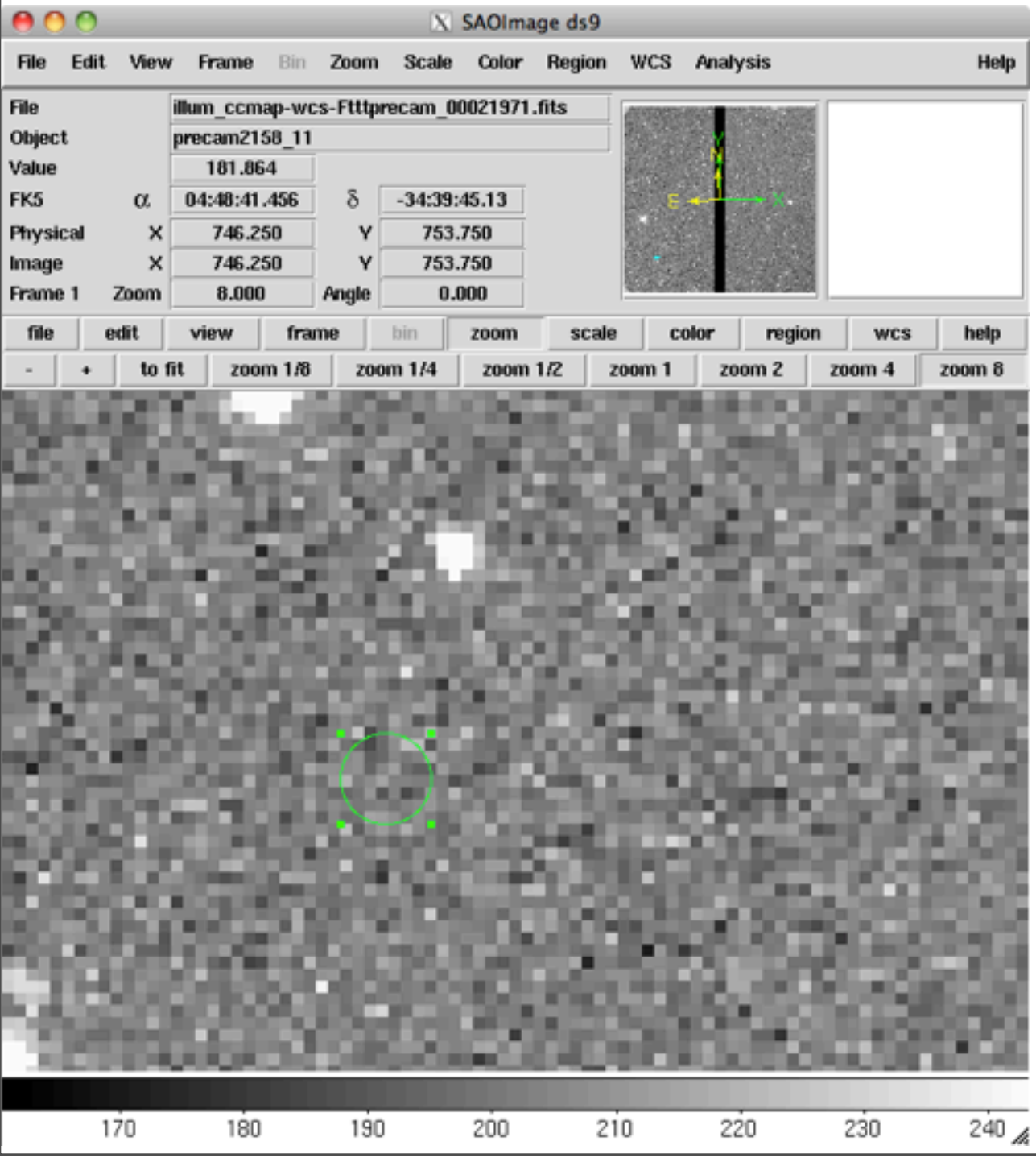
Moving Shutter region to centerline, Weighting BG points improves separation.
NO false positives, only 2 false negatives (detectable by eye)



ccmap-*.fits
Highlighted Dipole
at x,y = 756, 740:
Top = 242.3
Bottom = 174.3
+/- 34 from mean
+/- 16% from mean



Illumination Map
same x,y
Top = 1.079
Bottom = 0.838



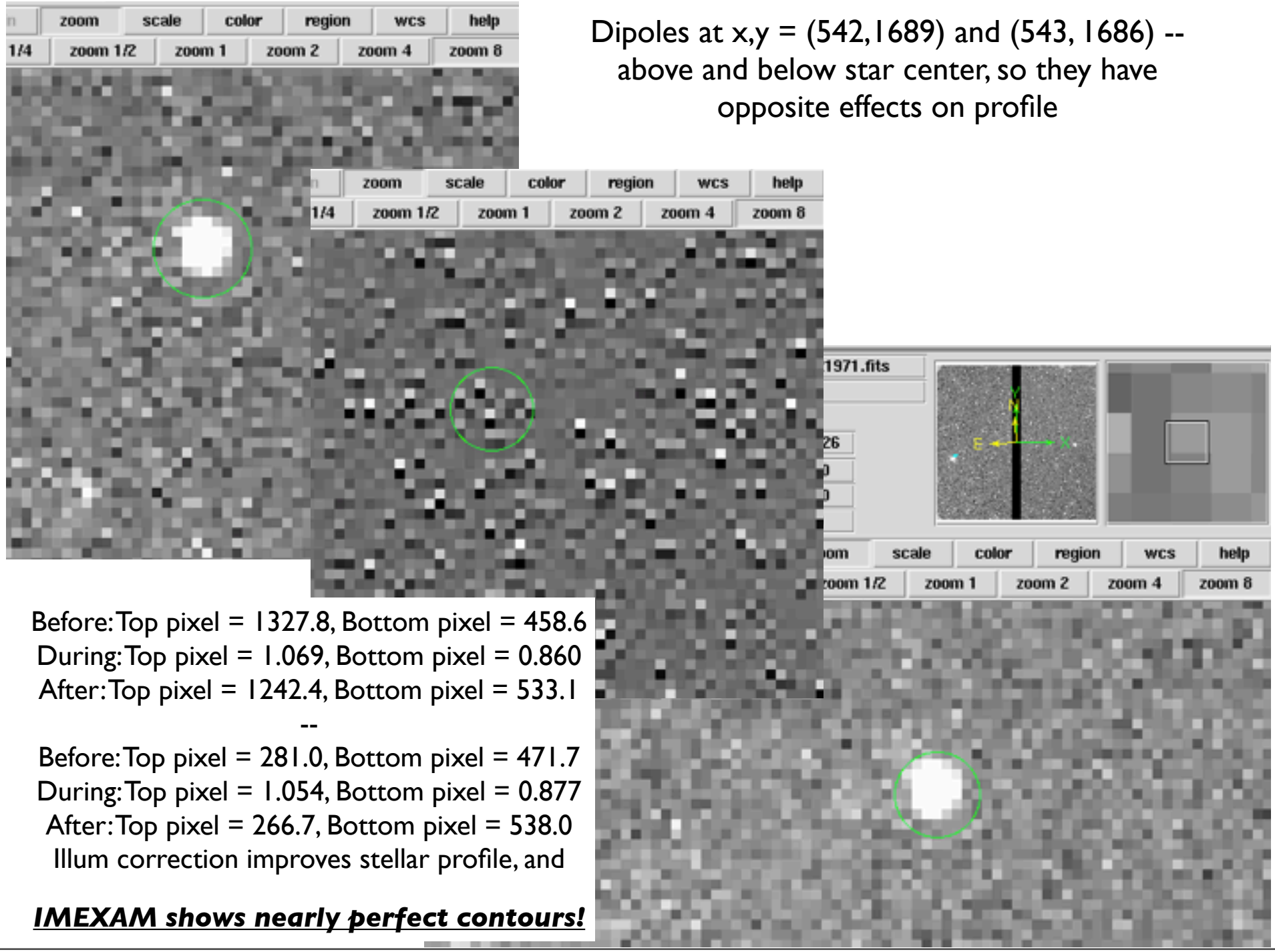
illum_ccmap-*.fits
same x,y
Top = 214.4
Bottom = 188.9

+/- 12.8 from mean
+/- 6.3% from mean

from original mean:
+6/-20
+2.9%/-9.6%

Dipoles reduced to ~background levels!

Dipoles at x,y = (542,1689) and (543, 1686) -- above and below star center, so they have opposite effects on profile



Before: Top pixel = 1327.8, Bottom pixel = 458.6
During: Top pixel = 1.069, Bottom pixel = 0.860
After: Top pixel = 1242.4, Bottom pixel = 533.1

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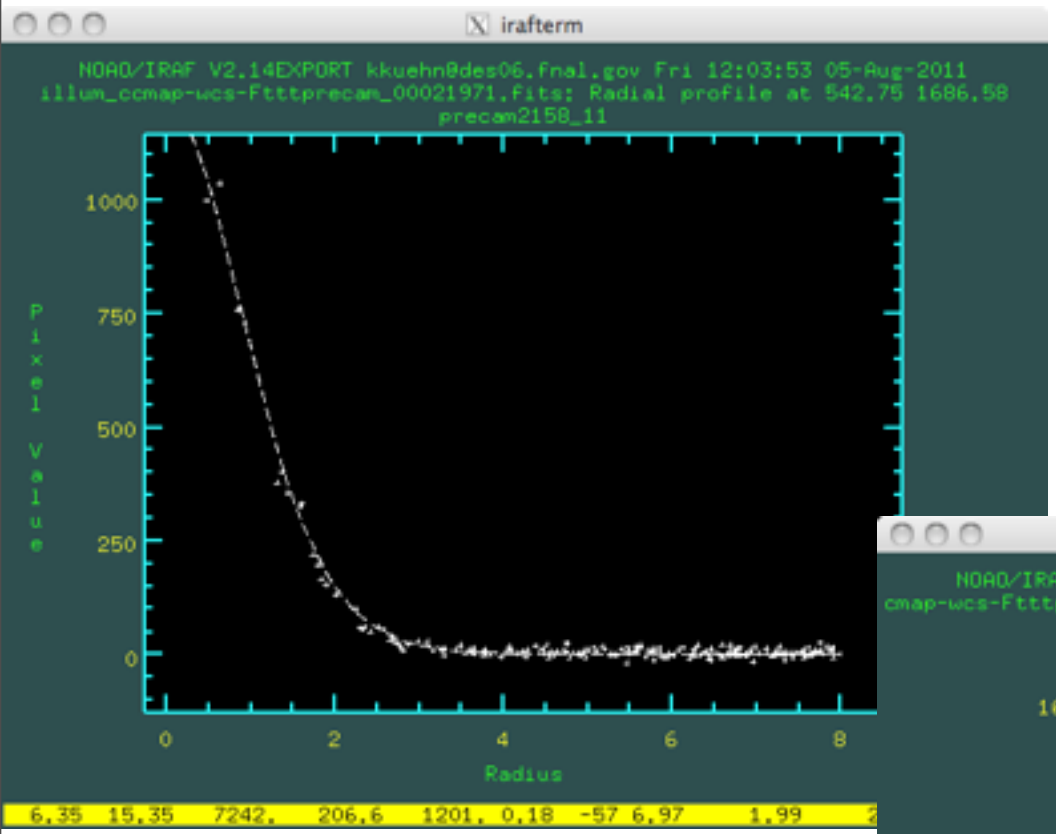
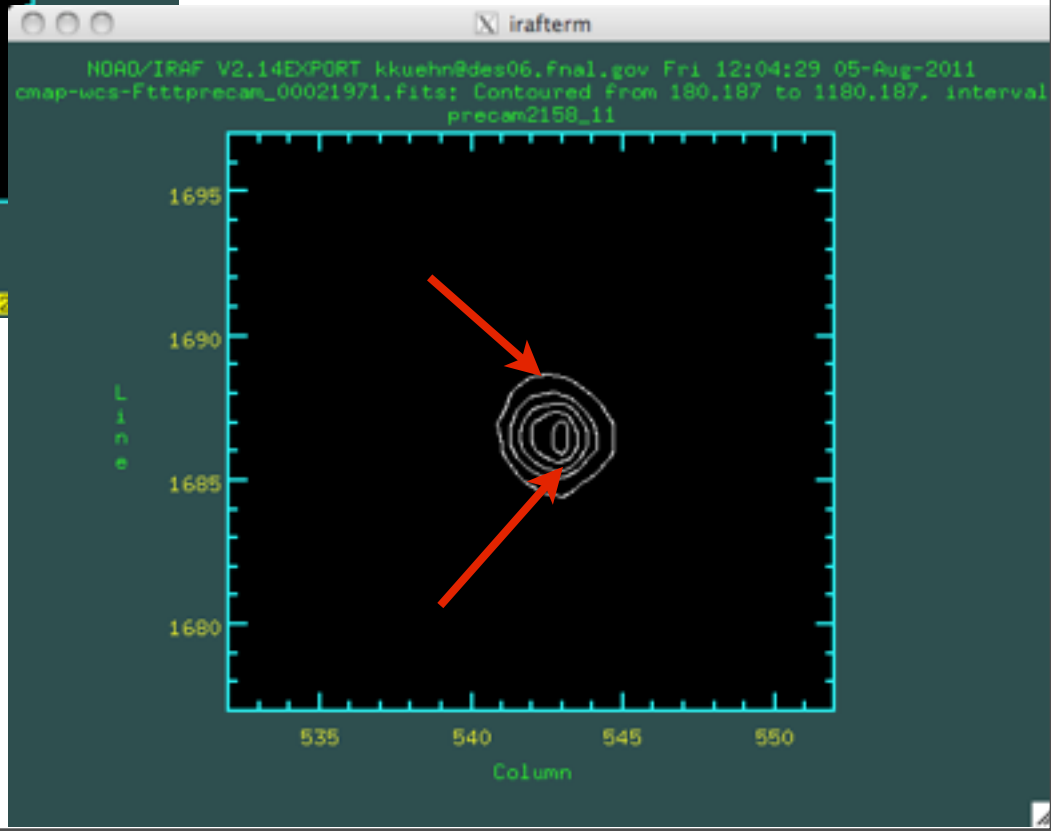
Before: Top pixel = 281.0, Bottom pixel = 471.7
During: Top pixel = 1.054, Bottom pixel = 0.877
After: Top pixel = 266.7, Bottom pixel = 538.0

Illum correction improves stellar profile, and

IMEXAM shows nearly perfect contours!





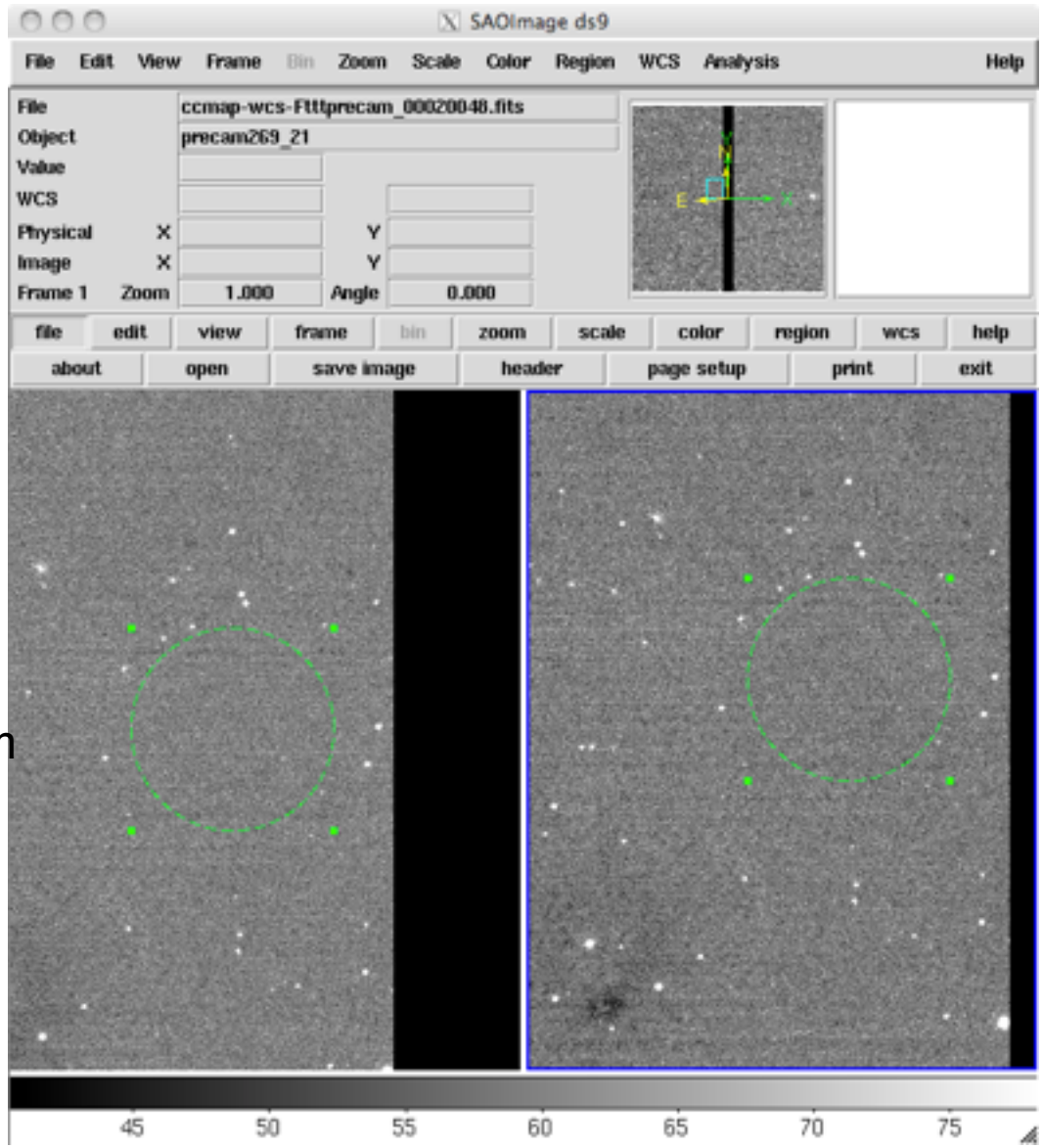
However, Illumination correction didn't improve photometry significantly...

Imstat Tests:

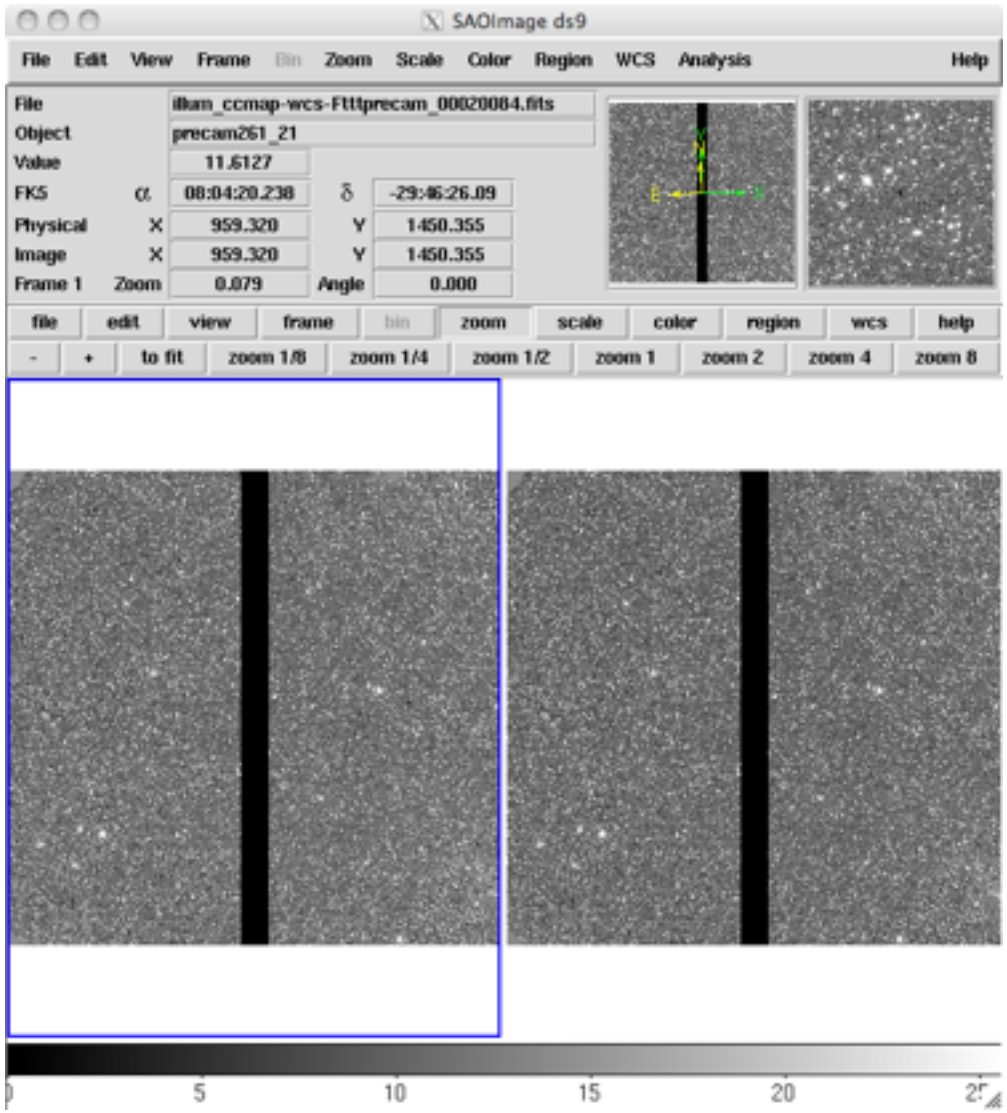
Before and after illum corr, photometry was comparable, and in some cases better without illum correction.

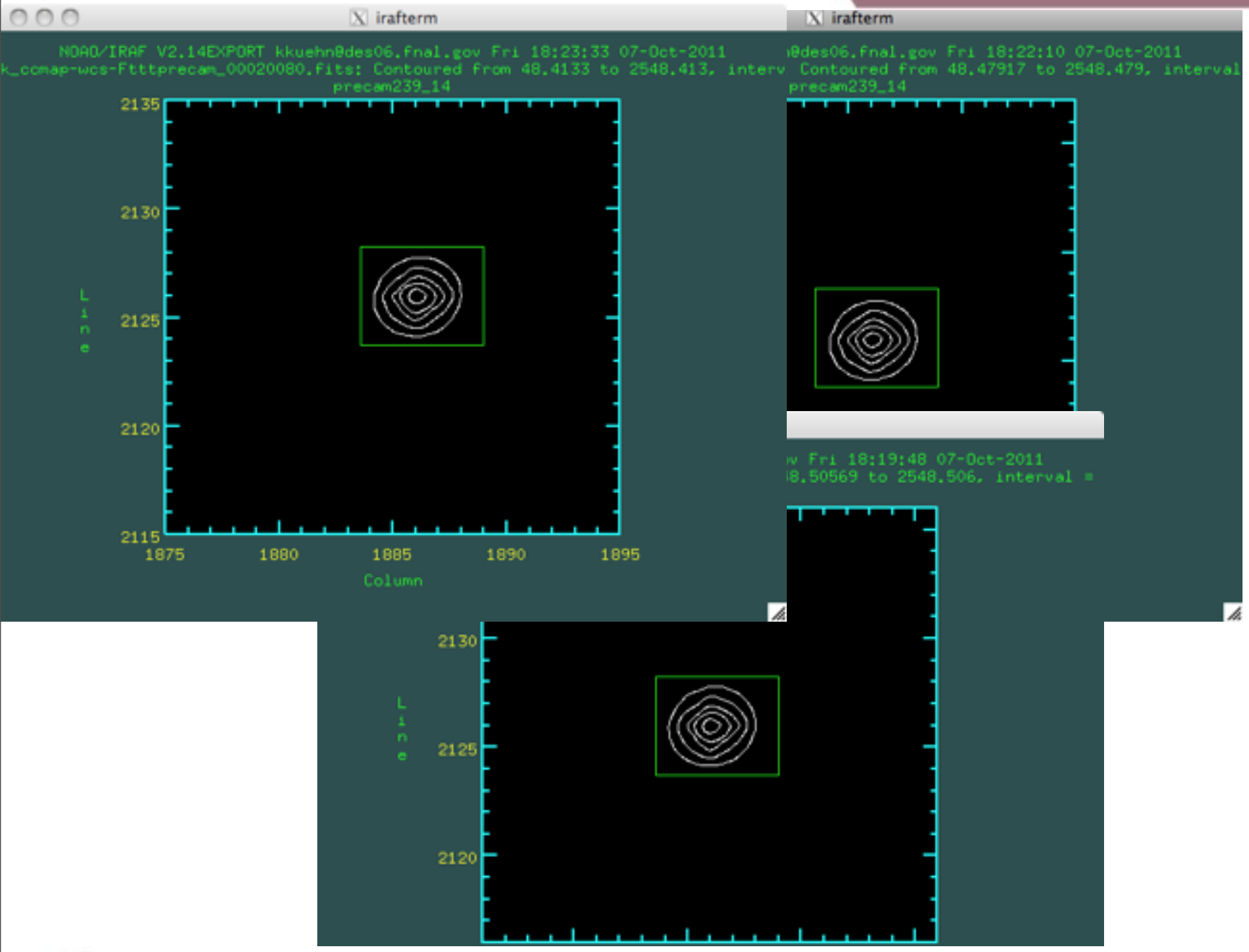
This was determined *not* to be an effect of noise/statistics of images that were combined to derive illumination maps...

Comparable noise before and after Illumination maps were created from daily images as well as weekly...

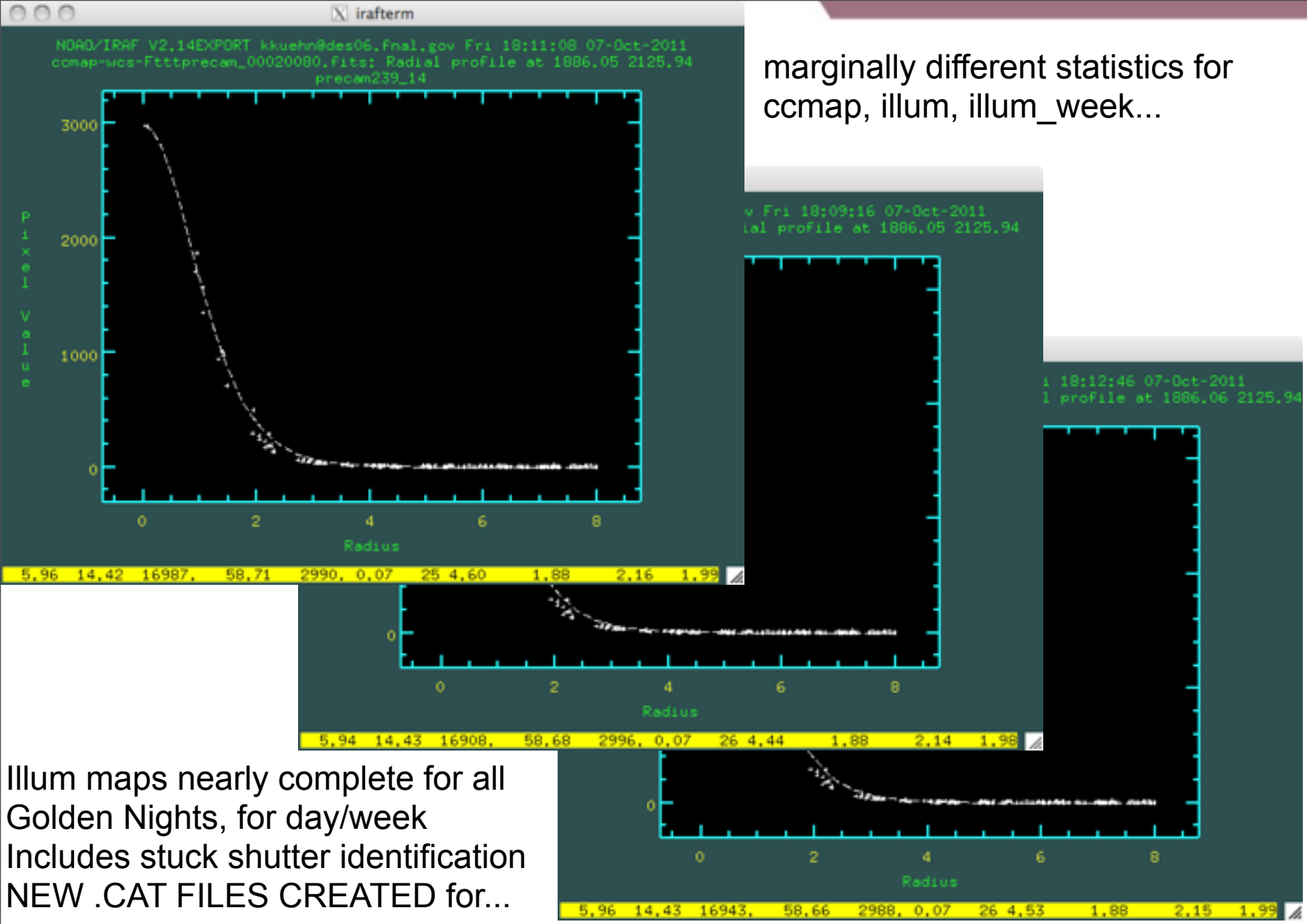


Illumination map comparison 1 day vs. 1 week




irafterm
NOAO/IRAF V2.14EXPORT kkuehn@des06.fnal.gov Fri 18:23:33 07-Oct-2011
k_ccmap-wcs-Ftttprecam_00020080.fits: Contoured from 48.4133 to 2548.413, interv
precam239_14
2135
2130
2125
2120
2115
Line
1875
1880
1885
1890
1895
Column
irafterm
@des06.fnal.gov Fri 18:22:10 07-Oct-2011
Contoured from 48.47917 to 2548.479, interval
precam239_14
v Fri 18:19:48 07-Oct-2011
8.50569 to 2548.506, interval =
2130
2125
2120
Line

marginally different statistics for ccmap, illum, illum_week...



Illum maps nearly complete for all Golden Nights, for day/week
Includes stuck shutter identification
NEW .CAT FILES CREATED for...

v3 (SExtractor) Photometry

- Using FNAL v3 production + ANL ROOT scripts

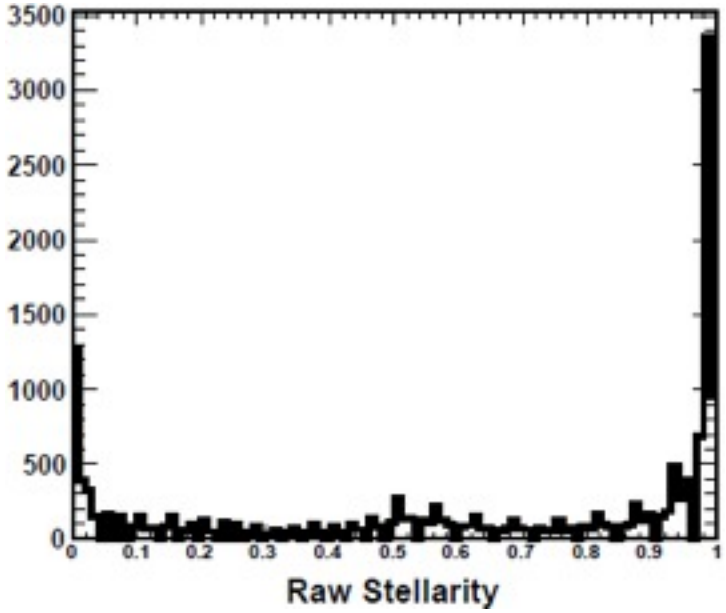
- Applying SDSS airmass correction
- Using USNO, Southern u'g'r'i'z', and SDSS standards
- Cutting USNO, Southern, and SDSS magerr<.01 for all bands

- "v3aper10"
  - aper10 and fwhm<4.
  - stellarity > .95
- Starflats applied to SDSS

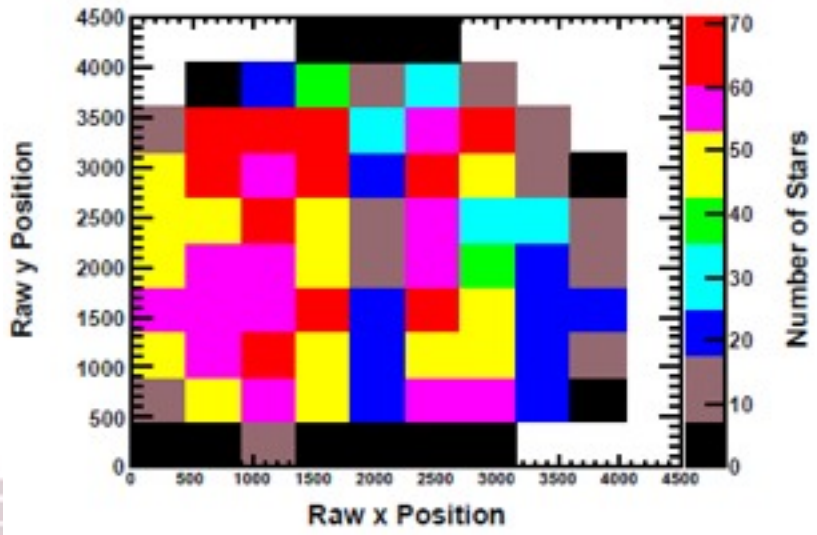
Evaluation of photometric error improvement per cut

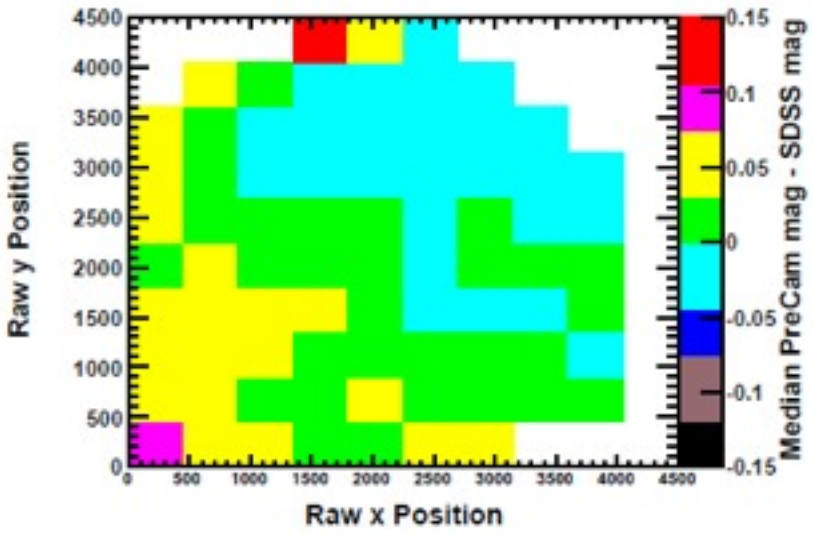
Version	Standard Deviation
v2aper12	.06973
v3aper12	.06871
v3aper12, stellarity > .95	.04901
v3aper10, stellarity > .95	.048496
v3aper10, stellarity > .95, fwhm < 4.	.048434
v3aper10, stellarity > .95, fwhm < 4. , pixels cut	.048447
v3aper10, stellarity > .95, fwhm < 4. , pixels cut, starflats	.040106
v3aper10, stellarity > .95, fwhm < 4. , pixels cut, starflats, mag < 17.	.03838

20110108 SDSS r-band science images



Pixels cut: 2010<xpos<2250





v2aper12 vs. v3aper10 – Southern Standards

Date	Zero-Point Offset (Southern Standards) – v2, aper12	Zero-Point Offset (Southern Standards) – v3, aper10	Standard Deviation (Southern Standards) – v2, aper12	Standard Deviation (Southern Standards) – v3, aper10
20110107	g: .7747	g: .81565	g: .05225	g: .02219
20110112	g: .7955 r: .1805	g: .821 r: .16541	g: .02195 r: .04771	g: .02043 r: .01888

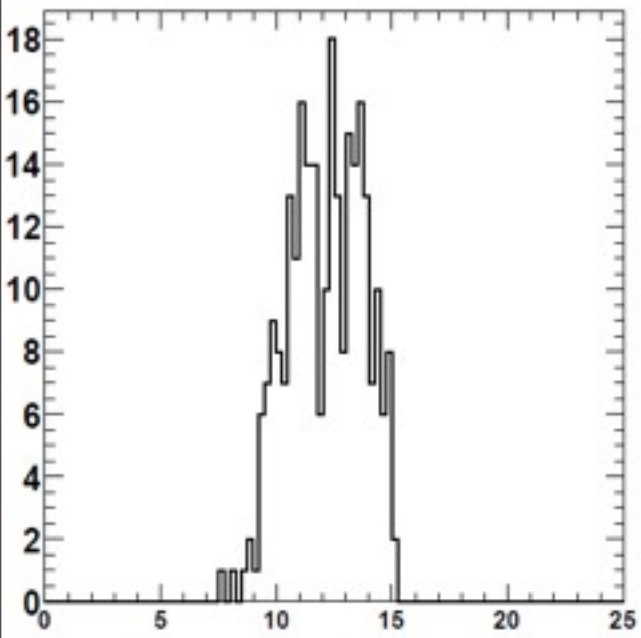
- Using science images
- 3 outliers are from image 21882
- Image 21882 has diagonal streak in ds9 and is not flagged in bad image filters.

v2aper12 vs. v3aper10 - SDSS

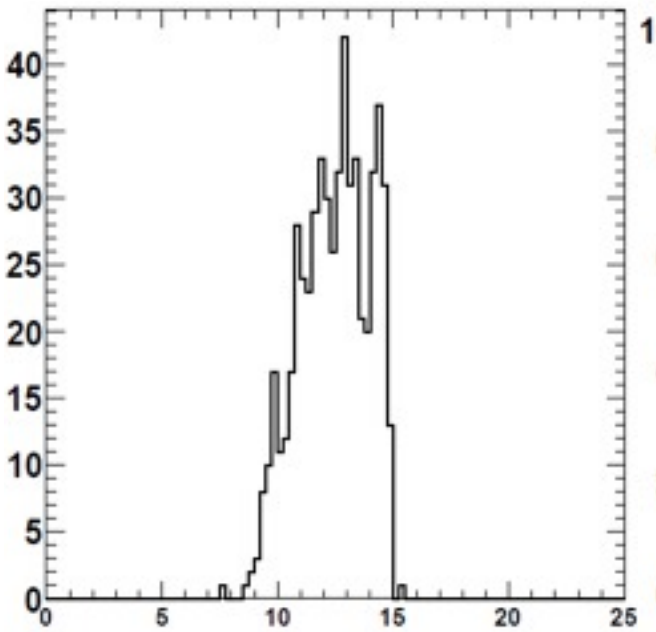
Date	Zero-Point Offset (SDSS), v2 aper12	Zero-Point Offset (SDSS), v3 aper10	Standard Deviation (SDSS)-NoMagCut, v2 aper12	Standard Deviation (SDSS)-NoMagCut, v3 aper10	Standard Deviation (SDSS)- mag<17, v3 aper10
20110107	g: .83159 z: -.74	g: .81859 z: -.71	g: .08784 z: .07515 RA0to50	g: .04731 z: .0446 RA0to50	g: .04554 z: .0445 RA0to50
20110108	r: .21637 z: -.686	r: .22637 z: -.6552	r: .06973 z: .07761 RA0to50	r: .04011 z: .04484 RA0to50	r: .03838 z: .04484 RA0to50
20110112	i: .03895 z: .-.7865	i: .03044 z: .-.7645	i: .08617 z: .06198 RA40to50	i: .0485 z: .03803 RA40to50	i: .04832 z: .03803 RA40to50

- Using science images
- Starflats have been applied

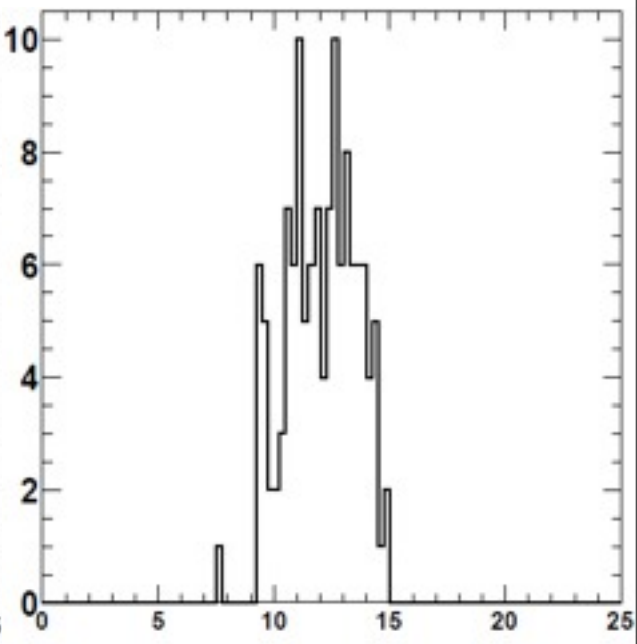
Standard Magnitudes, USNO



20110107



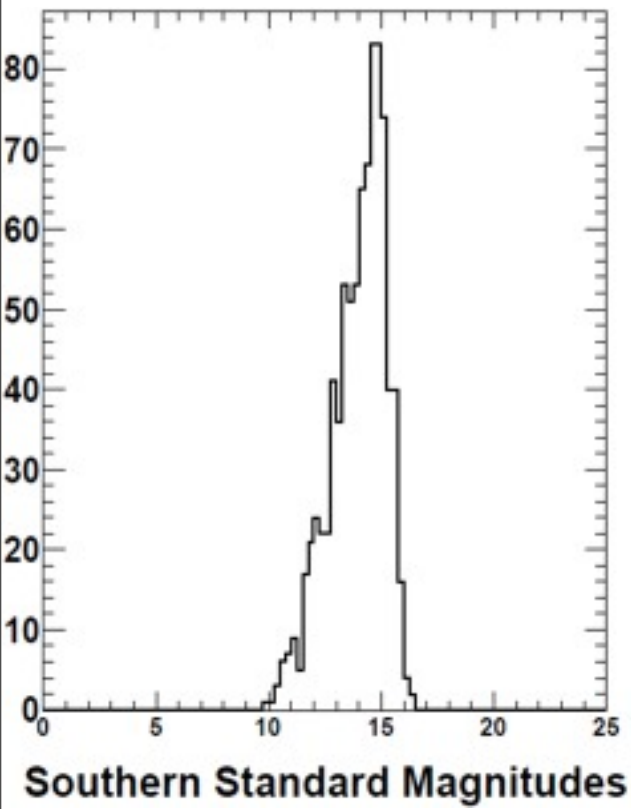
20110112



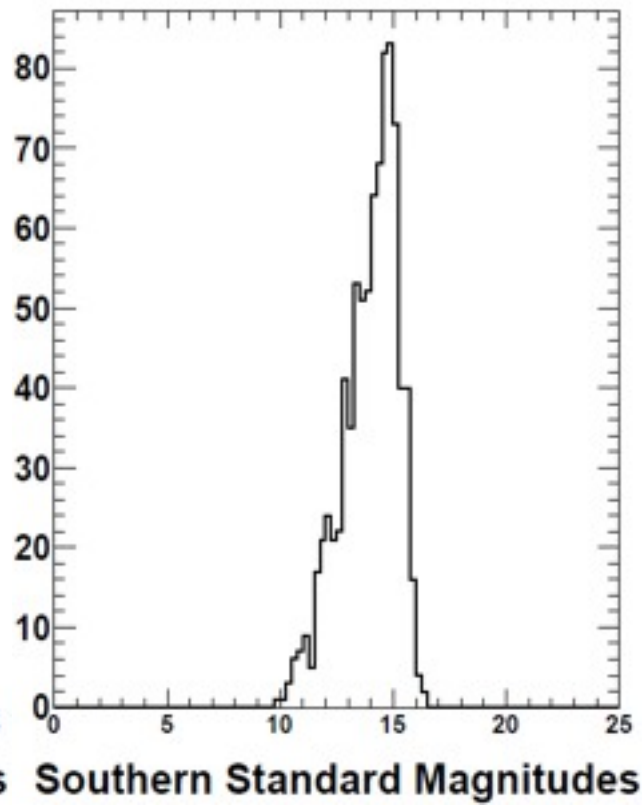
20110113

- All plots have magerr<.01

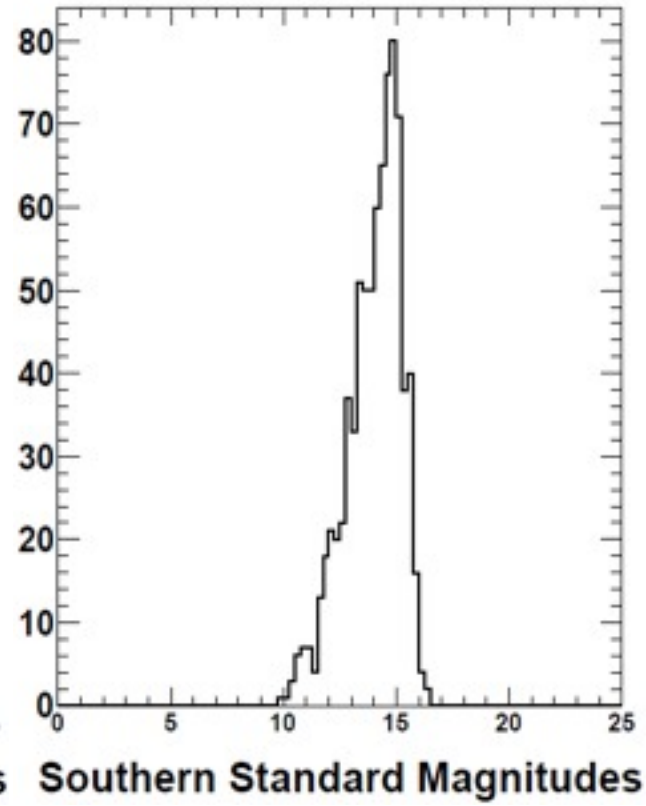
Standard Magnitudes, Southern Standards



20110107



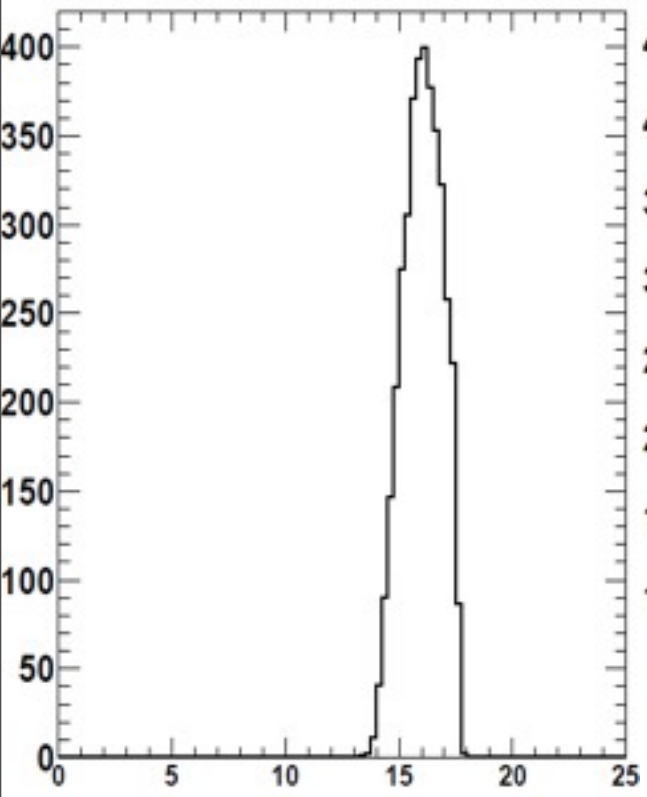
20110112



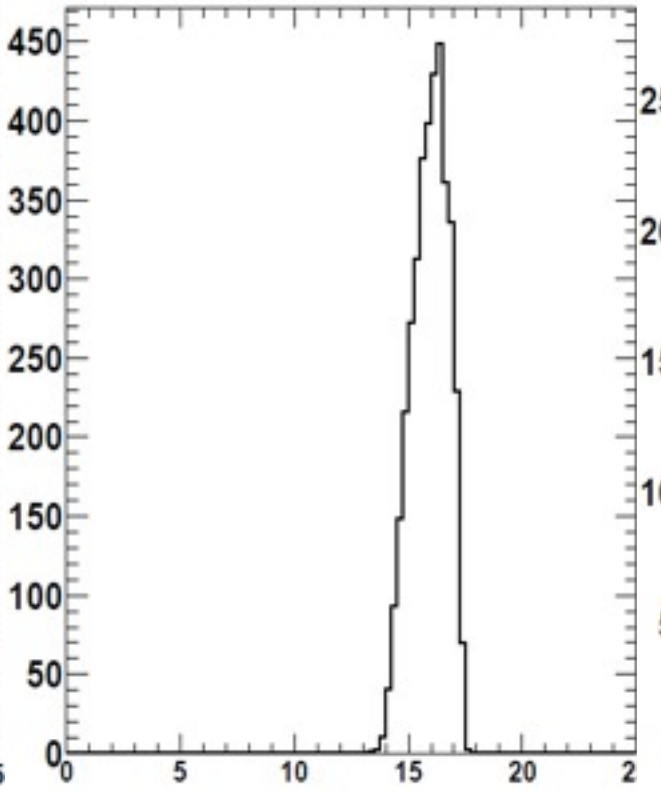
20110113

- All plots have magerr<.01

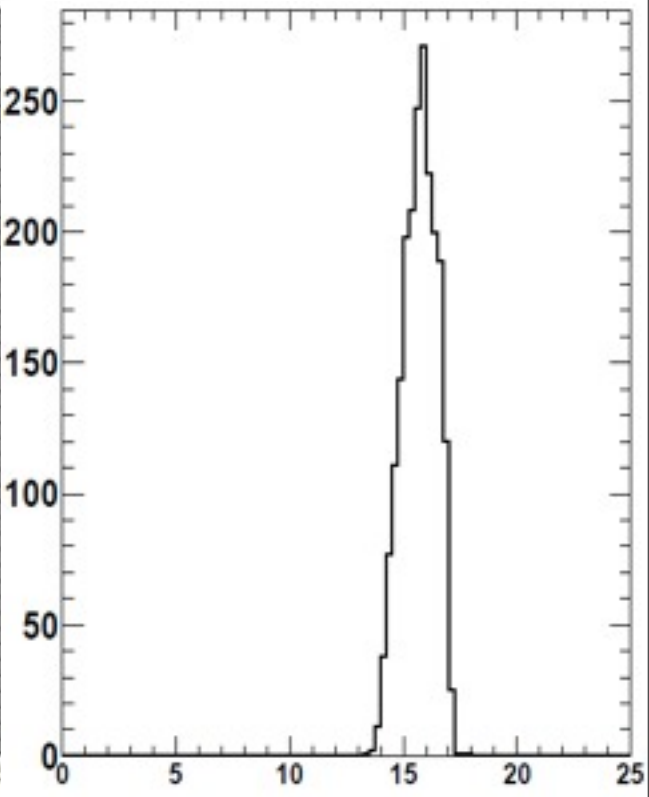
Standard Magnitudes, SDSS



20110107



20110112

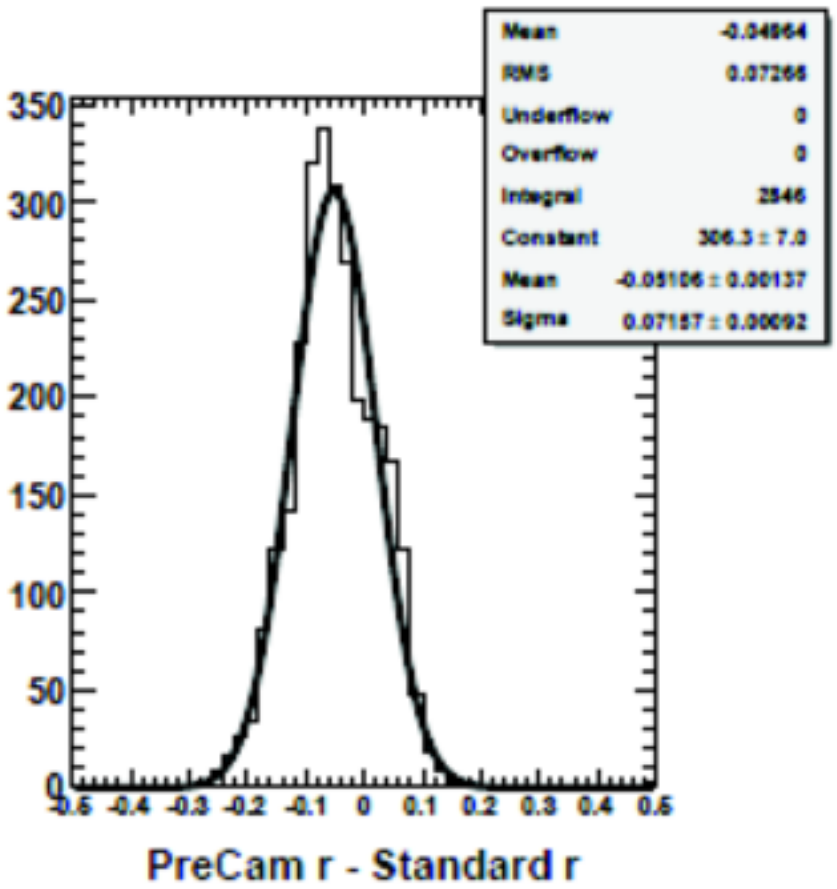


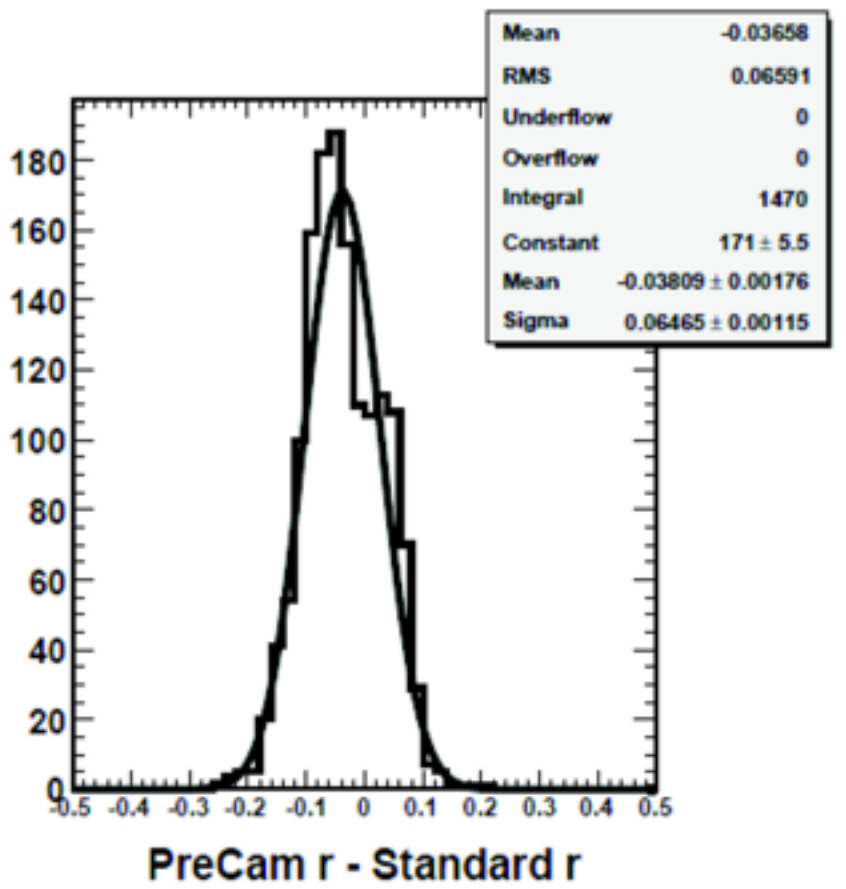
20110113

- All plots have magerr<.01

Date	Zero-Point Offset (USNO)	Standard Deviation (USNO)	Zero-Point Offset (Southern Standards)	Standard Deviation (Southern Standards)	Zero-Point Offset (SDSS)- RA40to50	Standard Deviation (SDSS)- mag<15	Standard Deviation (SDSS)-NoMagCut
20101215			g: 2.3372 r: 2.1269 i: 2.2864 z: 2.5072	g: .05323 r: .05176 i: .05021 z: .06227	g: 2.17425 r: 1.95941 i: 2.12993 z: 2.32859	g: .05258 r: .04194 i: .0581 z: .05982	g: .08925 r: .09445 i: .1065 z: .08172
20110107	g: 2.08978 r: 1.899857 i: 2.05227 z: 2.247	g: .02374 r: .03213 i: .03222 z: .02319	g: 2.0802 r: 1.91872 i: 2.05298 z: 2.263	g: .02843 r: .04228 i: .02944 z: .04915	g: 2.0645 r: 1.9346 i: 2.07891 z: 2.2993	g: .04711 r: .04305 i: .05134 z: .05304	g: .09277 r: .09258 i: .09468 z: .08514
20110108	g: 2.1784 r: 1.98041 i: 2.1281 z: 2.3587	g: .07305 r: .06301 i: .05031 z: .05476	g: 2.12746 r: 1.93154 i: 2.24 z: 2.3044	g: .03003 r: .04221 i: .04874 z: .03008	g: 2.1617 r: 1.94502 i: 2.10669 z: 2.3456	g: .05267 r: .03744 i: .05214 z: .05843	g: .1057 r: .09614 i: .1025 z: .07865
20110112	g: 2.1035 r: 1.932 i: 2.0765 z: 2.248	g: .03165 r: .05489 i: .04316 z: .04514	g: 2.07424 r: 1.905615 i: 2.06179 z: 2.21012	g: .02947 r: .03518 i: .03624 z: .03695	g: 2.11098 r: 1.92643 i: 2.07017 z: 2.25469	g: .04387 r: .03939 i: .04554 z: .05621	g: .08868 r: .08243 i: .102 z: .08538
20110113	g: 2.08618 r: 1.90392 i: 2.05038 z: 2.21058	g: .02186 r: .02544 i: .02691 z: .02033	g: 2.07 r: 1.89748 i: 2.06527 z: 2.20684	g: .03127 r: .03662 i: .04353 z: .03638	g: 2.143606 r: 1.9298 i: z: 2.26745	g: .02575 r: .04268 i: z: .06571	g: .09088 r: .08401 i: z: .0936

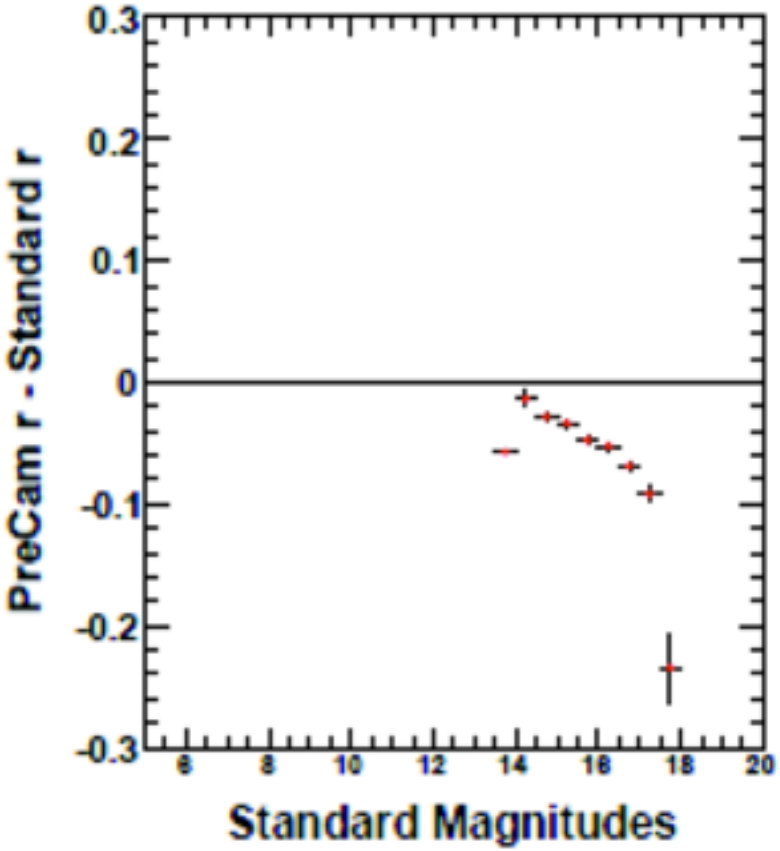
DAOPHOT Results

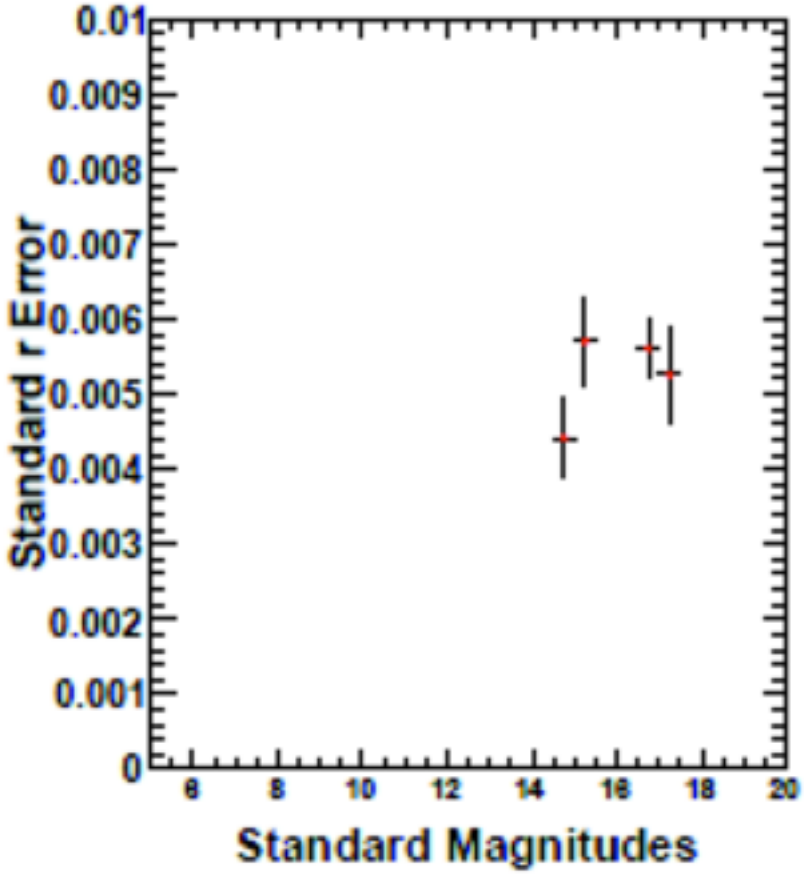




- Six images from 8 Jan were analyzed with SDSS matches.
  - With just Douglas' cuts (FWHM < 4, stellarity > 0.95), σ = 0.07 (left).
  - With an additional magcut < 16, σ = 0.065 (right).

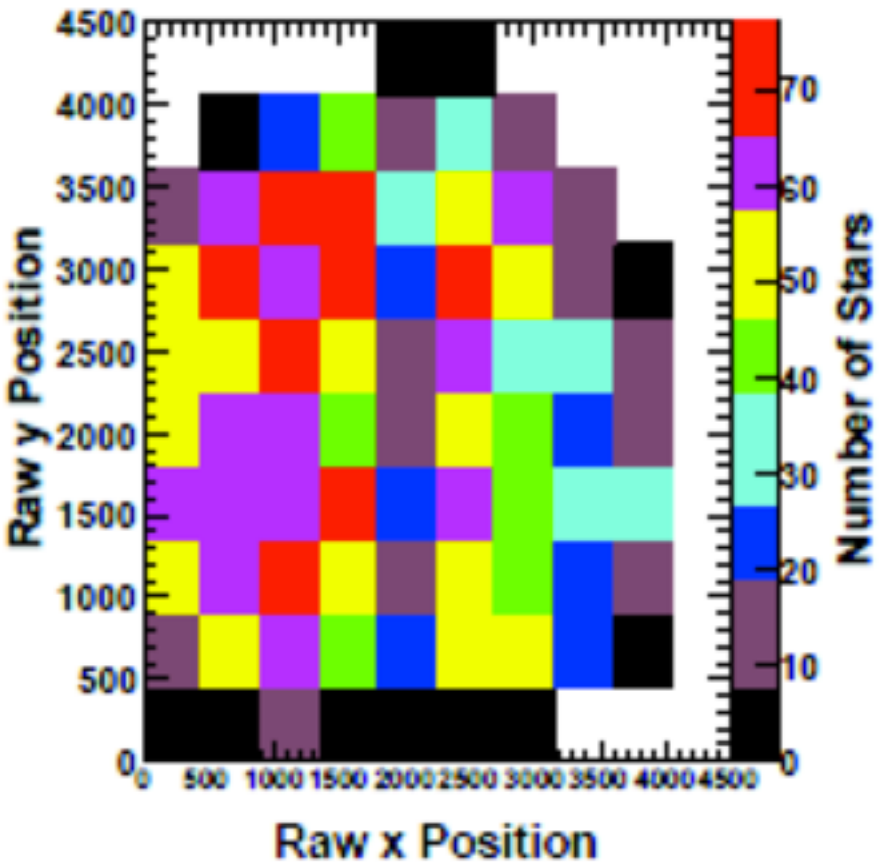
DAOPHOT Results (cont.)

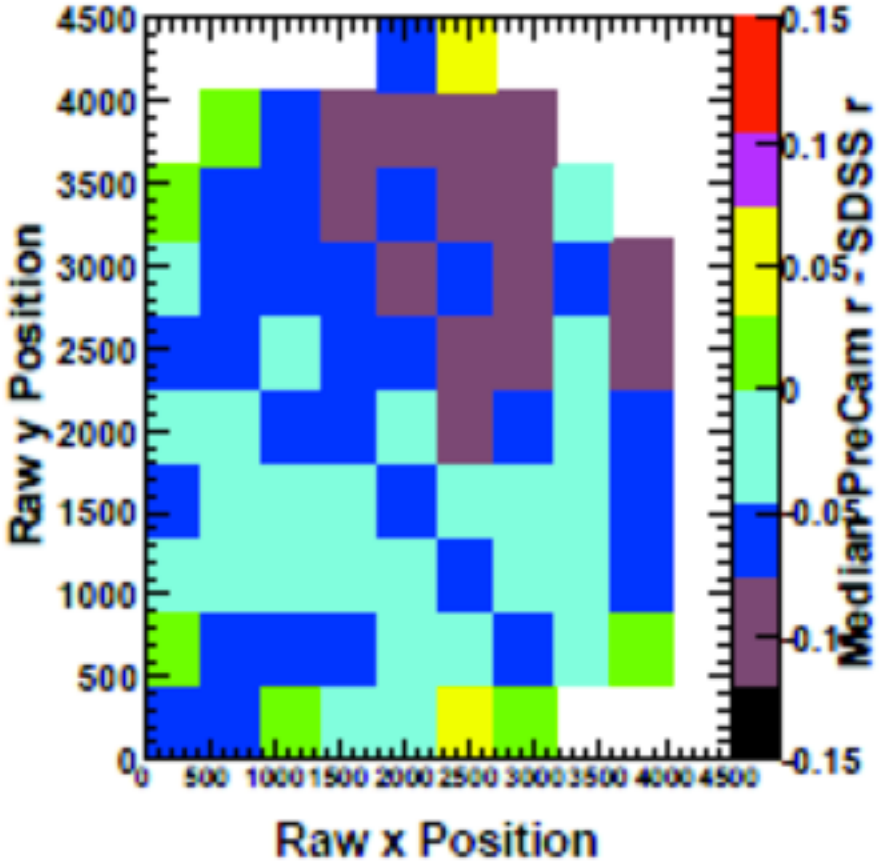




- Results from Douglas' cuts only (no additional mag cut)
- Systematic offset? Is DAOPHOT configured properly?

DAOPHOT Results (cont.)





- Results from Douglas' cuts only (no additional mag cut).
- Error Correlated with position...?

To Do:

- Put everything together...v3+ processing, bad image removal & illumination correction, then:
- Photometry
  - DAOPHOT?
  - PSFEx
  - SDSS reCalibration? (Errors of ~4% > USNO, Southern Standard of 2%)
- Catalog
- Incorporate Streak Correction, Bad Image Detection/Correction, Illumination Maps into Brazil Pipeline